

EFFICIENT LIGHTING PROGRAMS IN EUROPE: COST EFFECTIVENESS, CONSUMER RESPONSE, AND MARKET DYNAMICS

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Abstract—Since 1987 more than 50 utility-sponsored programs in 11 European countries have offered financial incentives to promote energy-efficient compact fluorescent lamps (CFLs). Roughly 7.4 million households were eligible for the programs and together they acquired about 2.5 million CFLs. Data from 40 of the programs show that the average societal cost of conserved energy is 2.1 cents/kWh, including 0.3 cents/kWh for program administration and marketing, far less than the cost of building and operating new electric power plants. The highest penetration rates and the most cost-effective programs result when utility companies pay a high proportion (or all) of the cost of the efficient lamps. Data on lamp choice, placement, and utilization are presented along with a characterization of participants and non-participants. Survey results show that lamp prices can be a more important influence on consumers' choice of efficient lamps than the price of electricity. Non-economic factors such as environmental protection are as important as economic factors in determining participation. Market barriers, such as product shortages, are discussed along with appropriate remedies. Finally, differences between the European and the U.S. experiences are outlined.

INTRODUCTION

When the electric light was invented, lighting was regarded as a *service* rather than a product. Thomas Edison envisioned an industry that would prosper by providing cost-effective illumination services to its customers. From this vantage point, efficient lighting can be an important way to reduce the cost of providing the service and thereby to increase profits for the utility. An important vestige of this approach can be seen in modern street lighting where, in some areas, equipment is owned by utilities and the illumination services are purchased by local municipalities; i.e. customers are not billed simply for kilowatt-hours. Aside from this example, however, electric utilities abandoned the energy-efficient service paradigm through most of the 20th century. Yet with today's renewed interest in energy efficiency, utilities (along with other allies) have become a major catalyzing force in the creation and development of markets for energy-efficient products. This article describes the way this process has worked for lighting in Western Europe.

PERSPECTIVE ON THE MARKET FOR ENERGY-EFFICIENT LIGHTING

The choice of light sources and the markets for energy-efficient lighting have changed dramatically in recent decades. Among 16 countries surveyed, sales of incandescent light sources fell from ~90% of all lamps sold in 1960 to ~75% in 1990.[†] Compact fluorescent lamps (CFLs) are important substitutes for incandescent lamps. CFLs yield a light output of ~60 lumens/Watt as compared to ~15 lumens/Watt for the incandescent lamps they replace. Based on the European ratings for lamp life, each CFL provides as much light as about eight incandescent lamps.

Global CFL sales have grown rapidly, reaching 114 million/year in 1991. Lighting industry sources estimate that sales will exceed 250 million/year by 1995 (Fig. 1), with sales growing especially quickly in countries that have active programs offering financial incentives for consumers to purchase

[†] These data represent Austria, Czechoslovakia, Denmark, the former Federal Republic of Germany, Finland, France, the former German Democratic Republic, Great Britain, Hungary, Italy, Japan, Netherlands, Poland, U.S.A., the former U.S.S.R., and Yugoslavia.

CFLs. Global incandescent lamp sales, in contrast, were over 9 billion/year in 1991. Incandescent lamp sales continue to increase in many countries but are stagnant or declining in countries with significant CFL sales. For example, in Denmark, one of the most active countries in promoting CFLs, incandescent sales declined by about 6% between 1989 and 1991. Adjusting for CFLs' longer service life, one can infer that new CFL sales are effectively capturing 30 to 40% of the market in countries with aggressive programs. Globally, the market share is approximately 10%.

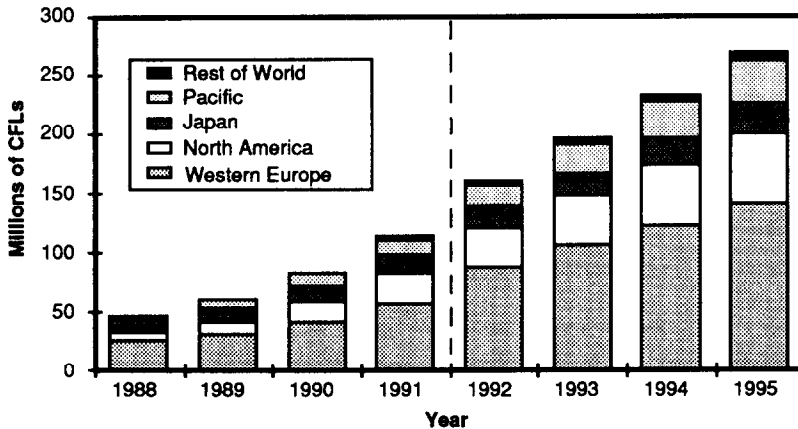


Fig. 1. Global compact fluorescent lamp sales (integral and modular lamps) by region. Source: lighting industry estimates, with projections after 1991.

New programs have clearly accelerated CFL sales growth. In Stockholm, for example, half of the CFL sales in 1989 were attributed to the programs. The sales growth rate between 1987 and 1989 was 59%/year versus 14%/year for the rest of Sweden. In the Netherlands, Denmark, and Ireland, CFL programs increased retail sales by a factor of three.

One reason for these rapid developments is that an increasing number of parties that are not traditionally involved in promoting efficient lighting (utilities, governments, public interest groups, and others) are actively participating. Innovative approaches have used financial incentives to overcome the barrier posed by the substantial extra cost of CFLs. The key parties have been electric utilities, including both generating and distributing companies. Lighting retailers have in some cases shared in marketing and providing consumer information or offering in-store discounts (rebates). In one case, a government body, the Swedish National Board for Industrial and Technical Development (NUTEK), designed and financed lighting programs to be carried out by utilities. Government support has also been important in the Netherlands where the national Environmental Action Plan calls for 3.5 CFLs per household by 1995, and in France where the Environmental Protection and Energy Management Agency (Ademe) initiated a large program on the island of Guadeloupe.

The remainder of this article provides an overview and analysis of recent efforts by utilities to promote CFLs in 11 European countries. Previously analyzed cost effectiveness data and participation rates are updated here.² This article also presents new information about participant reactions to the programs, the number and placement of lamps distributed during programs, the use of these efficient lamps, and lessons learned for addressing barriers and improving future programs. Some key differences between the European and U.S. programs are noted.

PROGRAM IMPLEMENTATION AND EVALUATION

There is a large potential for improving the efficiency of lighting and all other major electricity end uses at a cost less than that of building new power plants.^{3,4} The question of *how* to go about improving efficiency is now in the forefront. As there are many proven methods for implementation, a combination of them should be used. For electricity, a systematic approach to improving the efficiency of energy use (often called demand-side management, or DSM) can be pursued. However, this requires a new planning and marketing paradigm that focuses on providing energy *services* rather than on the sale of *energy*.

Successful DSM programs achieve high participation rates and cost-effective energy savings (a variety of definitions can be applied) while delivering desired energy services and consumer satisfaction. In the following sections, information is presented to help construct an “impact evaluation” as well as a “process evaluation” of many European lighting programs.⁴⁻⁷ Table 1 provides a generalized framework for program evaluations and the type of information compiled in this article.

Table 1. A generalized framework for lighting program evaluation.

IMPACT EVALUATION	
Direct costs	<ul style="list-style-type: none"> • Equipment (lamps, controls, fixtures , etc.)
Indirect costs/benefits	<ul style="list-style-type: none"> • Marketing, salaries, evaluation, avoided lamp replacements, labor savings, etc.
Participation/penetration	<ul style="list-style-type: none"> • Numbers of customers eligible for the program • Percentage of eligible customers participating in the program • Numbers and kinds of energy-efficient technologies installed • Technologies per eligible customer (and % actually installed) • Consumers' intentions to buy the same kind of products in future • Direct and indirect sales because of the program
Energy use and savings	<ul style="list-style-type: none"> • Energy and peak demand; load-shape analysis; interaction with other end uses • Cost effectiveness (societal versus private perspectives)
Energy services	<ul style="list-style-type: none"> • Intensity (size of lamp replaced) • Quantity (hours/day lamp operation) • Quality (lighting quality) • Takeback (longer/shorter lamp operation)
PROCESS EVALUATION	
Participants and non-participants	<ul style="list-style-type: none"> • Demographics • Reasons for (not) participating • Perceived advantages/disadvantages of the efficient technologies • Assessment of misconceptions about the technologies • Consumer willingness to purchase efficient technologies as a function of lamp cost • Complaints
Comparative analysis	<ul style="list-style-type: none"> • Incentive types: rebates, loans, leasing, etc. • Delivery mechanisms: direct contact, mail, phone, etc.
Marketplace response	<ul style="list-style-type: none"> • Manufacturer reactions • Retailer, distributor, wholesaler reactions, etc. • Reasons for product shortages, if applicable
Utility impacts	<ul style="list-style-type: none"> • Financial • Administrative effort • Customer relations • Environmental • Political/institutional

This article focuses on societal economics. Thus, the cost effectiveness of lighting programs is computed in terms of a cost of conserved energy (CCE) to all parties, i.e. the direct costs to consumers, utilities, etc. per unit of energy saved plus indirect costs such as those for administration, marketing, and evaluation/surveys, annualized using a 6% real discount rate. Taxes on lamps and

electricity are excluded because these are income transfers rather than true societal costs. The impact of programs can be measured in terms of participation rates (e.g. percentage of eligible customers choosing to participate in a program), numbers of efficient end-use devices adopted, resulting energy savings, the cost effectiveness of achieved energy savings, and other benefits. In this article, "eligibility" is defined as having the opportunity to participate in a program, e.g. households receiving rebate coupons.

Post-program process evaluations must assess the reason(s) for participation (*and* non-participation) and other qualitative factors responsible for the impacts that have occurred. The reactions of groups other than energy consumers (e.g. lighting retailers, manufacturers, and utilities) are also important. Thorough process evaluations should also assess the effectiveness of program administration and marketing efforts.

ASSESSMENT OF EUROPEAN LIGHTING PROGRAMS

Between late 1987 and 1992, at least 52 financial-incentive programs for CFLs were implemented in Austria, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Sweden, Switzerland, and the U.K. The 7.4 million households eligible for the programs received 2.5 million CFLs. Program target groups ranged from a few thousand households to several hundred thousand. The size of the eligible population does not appear to have had an influence on program participation rates or cost effectiveness; programs can be successful in small or large cities. The average program duration was about six weeks.

Data on program characteristics, penetration rates, total program costs, and the cost effectiveness for 40 of the programs (available to 5.9 million households in seven countries) are presented in Table 2.[†] These data are based on post-program surveys and on information collected from the utilities, trade associations, manufacturers, and other parties involved in the programs.⁸⁻²⁰ To the extent possible, standard definitions are used to analyze and compare data. The data differ substantially in scope and depth but overlap in a number of important areas, which partially reflects that utilities have not always planned their programs with evaluation in mind.

Programs available to non-residential consumers have been offered in Denmark, Germany, the Netherlands, and Sweden. Six of the residential programs analyzed here were also available to commercial or industrial customers (see Table 2, note 5).² In the Swedish NUTEK program, the following utilities offered rebates for fixtures that accommodated CFLs: Gothenburg Energiverk, Stockholm Energi, Stora Kraft, Karlstad Energiverk, Halmstads Energiverk, and Nyköping Energi. Participation rates were rather low, probably because of limited product choice and availability.

Cost Effectiveness and Participation Rates

For the programs shown in Table 2, the average societal cost of conserved energy is 2.1 cents/kWh, of which 0.3 cents/kWh represents indirect costs. The average price paid by program participants was \$11/CFL. Non-participants also benefited because increases in lamp sales as a result of the programs prompted manufacturers to lower normal retail prices. In Denmark, for example, prices fell from \$50 (300 Dkr) in 1987 to \$20 (125 Dkr) in 1991, excluding the effects of inflation.²¹

Moreover, despite the utility's cost of administering the CFL programs, the programs achieved substantially *lower* overall societal costs of conserved energy than would have been the case if consumers had bought the lamps individually. This savings is a result of the low prices that utilities obtained when cooperating with lighting vendors or when buying lamps in large quantities. Utilities typically obtained prices that were about one-third to one-quarter of prevailing retail prices.

Participation rates can be characterized in various ways. On average, approximately 15% of eligible households chose to participate in the programs, from less than 1% to almost 100%. The participating households obtained an average of 2.3 CFLs. When allowed to acquire more than one CFL, participants chose anywhere from 1.8 to 8.1 lamps (Fig. 2). The number of lamps acquired because of the programs varied from 0.04 to 6 lamps per eligible household, with an average of

[†] The major programs for which cost data have not been assembled are Schleswig Holstein, Germany (20,000 CFLs); ENEL, Italy (15,000 CFLs); Bernische Kraftwerke, Switzerland (77,000 CFLs); and NUTEK, Sweden (4,800 CFLs).

Table 2. Summary data on European residential lighting programs.

Country: Utility S = Sweden / DK = Denmark / F = France NL = The Netherlands / FI = Finland IR = Ireland / D = Germany / A = Austria	Program duration (Days)	Type of utility*	Program description A-B-C ^b	Eligible households (HHs)	Lamps received due to program	Penetration (L/HH)	Lamps received per participating household	Participating households (%)	Price paid by consumer ^c (U.S.\$/lamp)	Cost of conserved energy ^d	
										Indirect (¢/kWh)	Total society (¢/kWh)
S: Stockholm Energi AB Program 1 (1987) Program 2 (1988) Program 3 (1989) Program 4 (1989)	5	G&D	Y-6-A,G	390,000	139,384	0.36	6.0	50%	9	1.5	4.7
	32	G&D	N-1-C,H,K	2,128	6,384	3.00	6.0	8%	0	0.1	2.7
	33	G&D	N-1-C,H,K	390,000	70,000	0.18	2.3	8%	8	1.6	4.6
	15	G&D	N-1-C,H,K	390,000	46,000	0.12	1.7	7%	8	1.6	4.6
	90	D	N-U-H,K,M	390,000	17,000	0.04	0.0	0%	16	1.6	4.6
S: Helsingborgs Energiverk (1988)	68	D	Y-1-A,G	53,000	35,000	0.66	1.0	66%	0	0.2	0.6
S: Malmö Energi AB (1989)	16	D	Y-U-C,G,K	136,197	23,562	0.17	2.3	8%	12	1.4	2.3
S: Kalmar Energi AB (1990)	42	D	Y-U-C,G,K	15,000	4,500	0.30	2.3		9	2.1	3.1
Sweden subtotal				594,197	202,446	0.34			8	1.3	3.7
DK: EFFE Program 1 (1988) ^e Program 2 (1989) Program 3 (1990) DK: BHHH (1989) DK: ARKE A/S (1989) DK: SEAS A/S (1989) DK: KOH/KKF (1989) DK: KØGE (1989) ^e DK: ELFO, ELRO, & Randers (1990) DK: NESA A/S (1990) ^{e,f} DK: KBV (1990) ^e DK: ELSAM [Odense, Dalum-Hjalleles] (1990)	30	D&Co-Op	N-5-A,B,E,G	12,000	30,000	2.50	3.8	100%	4	→	1.0
	62	D&Co-Op	N-4-D,H	4,000	15,000	3.75			0	→	1.1
	69	D&Co-Op	N-3-D,H	12,000	10,000	0.83			7	1.1	0.9
		D&Co-Op	N-U-H,J	12,000	5,000	0.42			12	0.3	1.3
	62	D&Co-Op	Y-U-B,C,G,I	23,492	12,000	0.51			20	0.2	2.4
	30	G&D, Co-Op	Y-2-A,F,G	23,860	8,361	0.35	2.0	90%	17	0.0	2.4
	90	D&Co-Op	Y-2-A,F,G	120,000	216,000	1.80			0	0.4	1.3
	30	D	Y-U-H,J	41,997	1,500	0.04	2.0	100%	20	2.0	4.2
	30	D	Y-2-A,G	5,990	11,980	2.00			0	→	1.0
	90	Co-Op	N-U-C,H,I,J	59,500	10,000	0.17			18	0.3	3.3
	48	G&D	N-5-H,I,J	407,720	259,263	0.42	4.8	5%	17	0.7	3.0
	14	G	Y-2-C,H,L	294,384	100,000	0.34			17	0.4	2.7
	47		Y-5-C,G,*	65,000	9,368	0.14	1.3	11%	13	1.1	1.8
				1,069,943	658,472	0.62			11	0.5	2.3
NL: Friesland (1988) ^e NL: EBA (1989) NL: GEB (1989) ^e NL: Other programs (1989)	53	G&D	N-2-C,E,H,I,K	250,000	150,000	0.60			13	0.1	1.8
	62	G&D	Y-2-C,H,I,K	375,000	200,000	0.53			10	→	0.9
	60	G&D	Y-2-C,H,I,K	191,500	75,000	0.39			10	0.2	1.2
	60	G&D	Y-2-C,H,I,K	2,333,500	748,375	0.32			10	→	1.8
	60			3,150,000	1,173,375	0.37	2.5	15%	11	0.1	1.7
D: Energie-Versorgungsunternehmen Schwaben A: KELAG (Province of Carinthia) ^e IR: Electricity Supply Board (ESB) (1990) FI: (1990) F: EDF (1992)	90	G&D	N-1-C	800,000	61,000	0.08	1.0	8%	6	0.4	1.7
	90	G&D	N-2-C,K	116,000	14,274	0.12			12	0.2	3.0
	2	G&D	Y-4-D,I,K	25,000	5,000	0.20	4.0	5%	15	1.1	4.4
	2	G&D	Y-1-A	17,000	17,000	1.00	1.0	100%	0	0.5	1.6
	59	G&D	Y-10-C,G,I	120,000	260,000	2.17	8.1	27%	13	0.4	2.7
Total or weighted-average				5,892,140	2,391,567	0.41	2.5	15%	11	0.3	2.1

Notes on Table 2.

- (a) Type of utility: G = generating company, D = distributing company, and Co-Op = cooperative.
- (b) A-B-C: A. program restricted to a particular lamp wattage (Yes or No); B. limits on number of lamps (Unlimited, or #); C. program delivery mechanism(s), according to the following key: A. Giveaways (to employees and/or customers); B. Direct installation; C. Rebate coupon or other form of retail discount: cash; D. Rebate coupon or other form of retail discount: "buy-one, get-one-free" schemes; E. Government subsidy to lamp buyers or utility; F. Government waivers of lamp luxury taxes; G. Bulk lamp purchase (* = with savings split between utility and retailer); H. Wholesaler lamp discounts to retail stores; I. Pay-on-your-bill approach; J. Retailer co-financing; K. Manufacturer co-financing (other than lamp discounts), e.g. promotion; L. "Kits" available containing a variety of CFLs for testing in the home; M. Information, but no financial incentive.
- (c) Lamp prices paid by consumers are net of rebates or other discounts, but include sales taxes.
- (d) The cost of conserved energy is the net annualized total cost (computed here with a 6% real discount rate) divided by annual electricity savings. The "societal cost of conserved energy" includes program costs (direct plus administrative costs), plus consumers' costs (less the value of avoided incandescent lamp purchases), plus any third-party financing (e.g. from government or retailers). Sales and value-added taxes on lamps are not included in the societal calculation (A 20%, D 14%, DK 22%, FI 20.48%, F 7.5%, NL 18.5%, IR 12.5%, S 23.5%). Mid-1989 exchange rates are used: 13.98 Austrian schillings/U.S.\$; 7.735 Danish kroner/U.S.\$; 2.24 Dutch guilders/U.S.\$; 4.4395 Finnish marks/U.S.\$; 6.6 French francs/U.S.\$; 1.9894 German deutschemarks/U.S.\$; 0.7060 Irish pounds/U.S.\$, and 6.700 Swedish kroner/U.S.\$.

Assumptions for electricity savings: Based on consumer surveys, the calculations assume a lamp operation time of 4 hours/day and assume that, on average, 60-Watt lamps are replaced. Annual electricity savings are 72 kWh/year per lamp (including 9% annual average transmission and distribution losses). This assumes that a 60-Watt incandescent lamp (1,000-hour service life, \$0.90 retail price) is replaced with a 15-Watt compact fluorescent lamp (8,000-hour service life). These lamp service lives are manufacturers' ratings for European conditions. Applying the assumptions normally used for North American conditions (10,000-hour CFL life and 750-hour incandescent lamp life) would lead to an average cost of conserved energy of 1.0 cent/kWh. Because of the highly case-specific and poorly understood nature of the issue, no adjustments have been made for interactions between lighting savings and space-heating or cooling energy use.

- (e) CFLs also available to non-residential customers. Associated costs and lamp sales not included in the analysis, except for the Dutch programs where it was impossible to disaggregate the cost data by customer type.
- (f) Lamps received due to the program include program-related lamp sales outside of the utility's service territory. Lamps per eligible household and participation rates shown in the table pertain only to the utility's customers.
- (g) Provincial generating companies: Groningen, North Holland, Gelderland, Friesland, Limburg, Zeeland, Overijssel, and Utrecht. City generating companies: Groningen, Breda, Amsterdam (EBA), and Den Haag (GEB).

0.41. Little information exists on the extent to which lamps were installed in homes outside of the sponsoring utility's service territory.

Lamp giveaway programs (no cost to household) resulted in the highest participation rates (lamps/eligible household) and the lowest societal costs of conserved energy. Aside from lamp giveaway programs, participation rates varied from ~1 to 30% of eligible households (in 13 programs surveyed). Between 8 and 34% of eligible households (in 6 programs) owned at least one CFL before the program. Between 17 and 100% of eligible households (in 6 programs) owned CFLs after the programs. At current lamp prices, between 7 and 38% of participating households (in 4 programs) do not plan to buy additional CFLs in the future.

In addition to the eligible participants taking advantage of financial incentives, a substantial number of "non-participants," people who would not otherwise have made such a purchase, bought CFLs.² These values are included in Table 2, where available. For example, the Swedish lamp manufacturers' trade organization estimates that the 75,000 rebate checks redeemed in the Stockholm Energi program "leveraged" 41,000 additional lamp sales. According to Dutch utilities, the GEB program resulted in 25,000 direct sales versus 50,000 indirect sales. The corresponding numbers for the first Dutch Freisland utility program were 60,000 and 40,000 CFLs. In Switzerland, 7,000 CFLs were sold because of the program and "normal" sales increased by 70,000.

Participation rates also reflect the importance of demographic factors. Single-family households in Sweden represented a greater proportion of program participants than they represented in the eligible populations (37% versus 12% for the Stockholm Energi program, 63% versus 49% for the

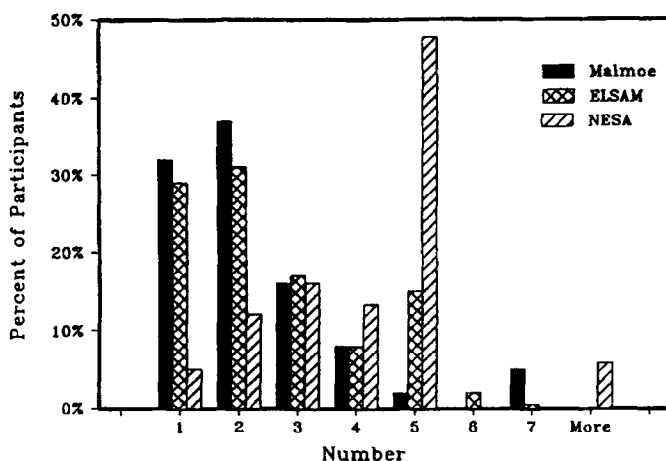


Fig. 2. Number of compact fluorescent lamps per participant. The NESA program was limited to 5 lamps per customer. Average penetration was 8.1 CFLs/household on Guadeloupe.

NUTEK program, and 63% versus 33% for the Malmö Energi program). The degree to which this reflects differences in factors such as income, renter-vs-owner tenure, or other variables has not been investigated. In Sweden, pensioners (retired) also represented a greater proportion of program participants than they represented in the eligible populations. In the 1989 Stockholm Energi program, 44% of the participants were retired persons, even though they represented only 26% of eligible households. The corresponding values for the NUTEK program were 38 and 27%. The possible greater value of convenience (long lifetimes) of CFLs and a relatively strong conservation ethic may provide a partial explanation.

Three post-program surveys investigated the question of whether CFLs obtained during the programs had actually been installed. The finding was that 92% of participating households had installed the lamps in the Malmö Energi program (including 8% planning to install or give the lamp as a gift), 90% in the SEAS program, and 97% in the Friesland program. In the initial Stockholm Energi "program," six CFLs were given to each employee, but only 50% of the lamps were installed. This can be attributed in part to the use of lamps with large, heavy electronic ballasts and to the fact that participants had no choice about which lamps they received or how many.

CONSUMER BEHAVIOR AND PREFERENCES

In addition to assessing cost effectiveness and participation rates, it is important to observe how consumers use their new lamps and how they respond to different marketing strategies.²² Various indicators of energy services can also be evaluated, e.g. sizes of lamps replaced, lamp placement, perceived lighting quality, and use of the new lamps compared to use of the old lamps.

Lamp Choice, Placement, Utilization, and Load-Shape Data

Four surveys indicate that 60-Watt incandescent lamps were the most commonly replaced. Participants in the Friesland and Stockholm Energi programs reported the following lamps replaced: 40 watts or less (31 and 15% respectively), 60 watts (46%; 40%), 75 watts (13%; 32%), and 100 watts (10%; 13%). The average lamp size replaced in the Pori program (Finland) was 63 watts and in the SEAS program 52 to 61. Seven surveys show where the CFLs were installed. From 7 to 32% of the lamps were placed outdoors, 14 to 48% in kitchens, 21 to 84% in living rooms, 2 to 10% in bedrooms, and 1 to 2% in bathrooms.

Various surveys investigated the time-dependent utilization of CFLs (Fig. 3). During winter months in Denmark and Sweden, average use is approximately 7 hours/day, while during summer months use drops to approximately 3 hours/day, averaging about 4 to 5 hours/day on an annual basis.^{23,14} The annual average in Finland is 4.4 hours/day.²⁰ These figures for average use times are larger than those often assumed in estimates of European savings potentials.

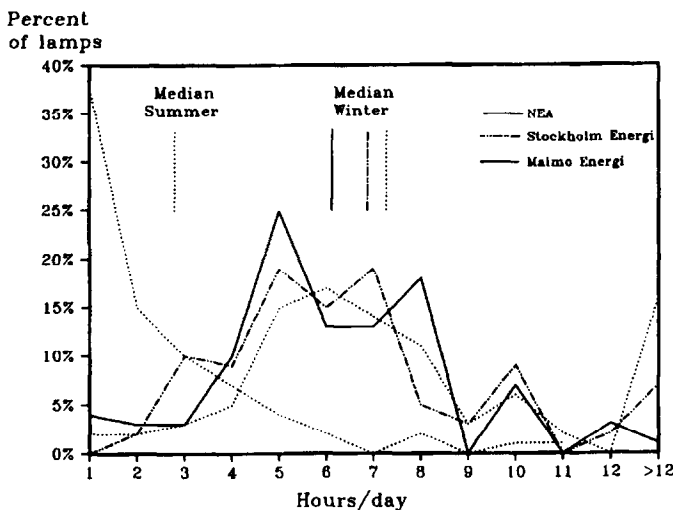


Fig. 3. Distribution of daily operating times of CFLs for three programs.

Several surveys attempted to determine how often CFLs were used compared to the incandescent lamps they replaced. In both the Stockholm Energi and SEAS programs, almost 5% of the households reported using their CFLs for a shorter time than they used their old incandescent lamps. Households used their CFLs longer in 34% of the cases for the Stockholm Energi program, 30% for Malmö Energi, and 0% for SEAS. Unfortunately, only in Finland were consumers asked *how much* longer they used their CFLs; their answer was 0.7 hours/day on average. In this case, if a 60-W incandescent was replaced by a 15-W CFL, the savings would be 4% lower than those predicted if operating times were assumed to be identical.

When advised to do so, customers seemed to install CFLs in high-use sockets. In one such case, the SEAS program in Denmark, two CFLs (240,000 total) were given to each household.^{10,23} (This is the largest give-away program so far in Europe.) Although only 7% of the lamps in homes were replaced, the old lamps were responsible for 20% of household electricity use for lighting. Thus, the use of two lamps resulted in a 15% ($20\% \times 75\%$) reduction in total residential lighting electricity use. Even greater savings are possible, given that Danish consumers reported that they could use, on average, 5.3 CFLs per single-family home. About 17% reported that they could use 10 or more CFLs.

In Denmark, detailed load-shape data were developed using a survey in which 1,200 households reported the number of CFLs burning during each hour of the day.²³ About 80% of the CFLs were in use during on-peak times. In a survey following an earlier program in Denmark, the utility ELSAM found that 87% of the CFLs were operating during peak hours (17:00 to 18:30).²⁴ The total annual hours that CFLs were used were allocated as follows: 25% during peak, 39% intermediate peak, and 36% off-peak times. Lamps obtained during the program in Pori Finland were operated during peak hours in 60% of the cases.²⁰

Two indicators of preferred lamp type have been described in post-program surveys: the type of ballast and the size of incandescent lamp being replaced. Lamps with electronic ballasts were used exclusively in programs in the Netherlands, in the ELSAM program in Denmark, and in the EDF program in Guadeloupe. They were used in 85% of the cases for NUTEK and NESA, 50% for SEAS, 35% for Malmö Energi, and 12% for Stockholm Energi. Electronic ballasts are more efficient than magnetic ballasts and less prone to shortened life when cycled frequently.

Participant Motivations and Market Segmentation

Program participants and non-participants are motivated by a spectrum of factors, as indicated by the ranges in Fig. 4. Non-economic motivations can be as important as economic factors in shaping consumer attitudes. Environmental protection through energy efficiency is often the most important non-economic motivation.

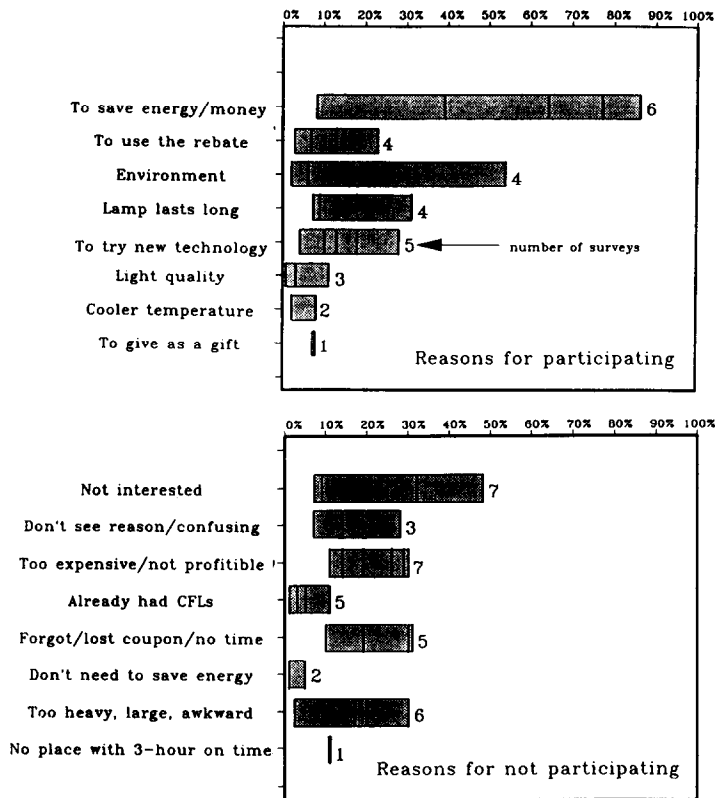


Fig. 4. Ranges of reported reasons for participating and not participating in the programs. Individual values are indicated by vertical lines and the number of surveys is indicated to the right of each bar.

Several surveys indicate that the *form* of an incentive (as opposed to its size) is important. For example, in Denmark and the Netherlands, consumers were given the option to pay cash for CFLs or to pay gradually via their electricity bills. In each case, approximately three-quarters of the participants preferred to purchase their lamps by making periodic payments on their utility bills. Furthermore, consumers in Denmark paying over a period of three utility bills bought 5 CFLs (the maximum number allowed) in 60% of the cases, whereas consumers paying in cash bought 5 CFLs in only about 15% of the cases (Fig. 5).²⁵ Pay-on-the-bill programs have also been used in France (EDF, 18-month payment period), Ireland (ESB, 1 year), Germany (Schleswig-Holstein, 7 years), and Sweden (Uppsala, 2 years).

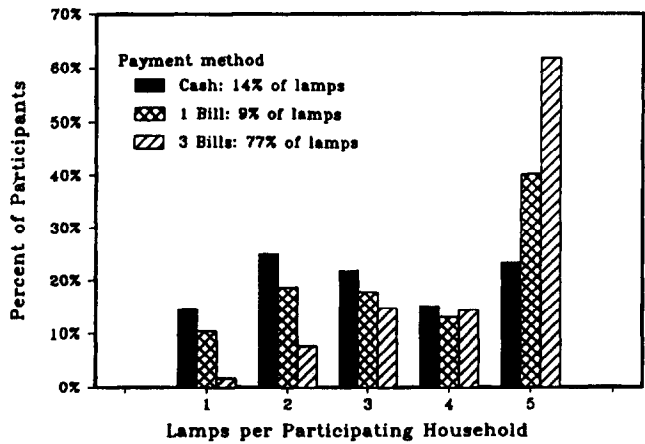


Fig. 5. Participation rates versus incentive type for the NESA program (single-family homes) [Denmark].

Three surveys have addressed the issue of consumer responsiveness to lamp costs. As shown in Fig. 6, reported willingness to purchase CFLs increases rapidly when the price falls to approximately \$10 to \$15/lamp. This corresponds to a threshold payback time of about one year. The similarity between the Swedish and Danish curves is notable, given that residential electricity prices are two times higher in Denmark. Not surprisingly, Swedish households choosing not to participate in one of the programs exhibited a noticeably larger reluctance to pay for CFLs than exhibited among participants. Half of these non-participants were unable to articulate an acceptable price.

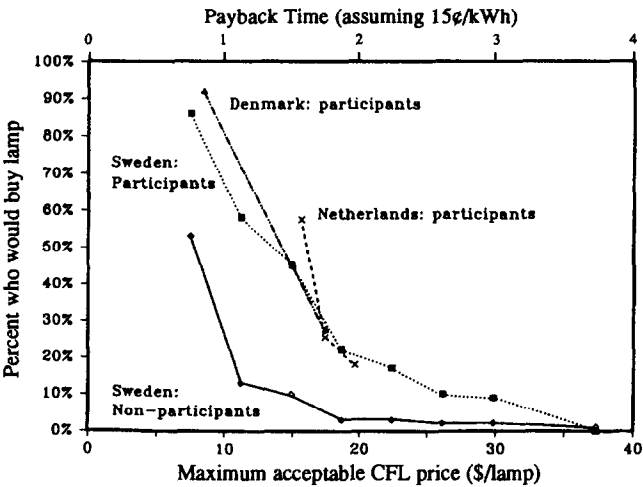


Fig. 6. Consumer cost-response curves. The curves show consumers' reported willingness to pay for CFLs. The Danish example is the ELSAM program, the Dutch example is the Friesland program, and the Swedish example is the NUTEK program. Exchange rates are shown in the notes to Table 2.

Only one survey looked in detail at differences between women's and men's reactions to the programs. Among the findings, women had a more positive reaction to the programs and were more willing to invest in energy efficiency (Fig. 7). Surveys have rarely been used to identify consumers' misconceptions about CFLs. However, the NUTEK program survey assessed consumers' awareness of the differences between CFLs with magnetic versus electronic ballasts. Very few respondents could correctly identify the important differences.

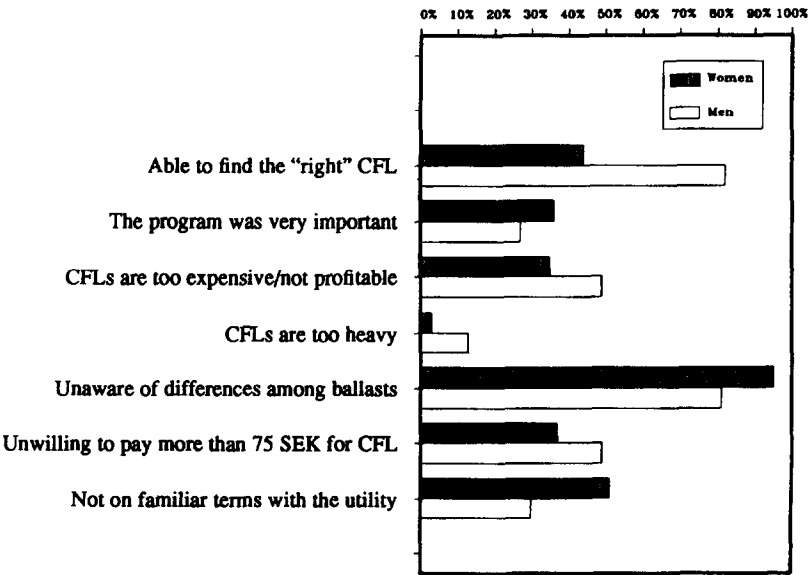


Fig. 7. Differences between women's and men's responses to the NUTEK program [Sweden].

LESSONS FOR MARKETING

A common finding is that the lighting programs have opened and increased the rate of market penetration for CFLs in the household sector where manufacturers previously saw little or no market. In Sweden, Denmark, and the Netherlands, programs increased residential CFL sales by four- to five-fold. However, much remains to be understood about effectively marketing lighting programs. The striking lack of correlation between the level of program costs and participation rates suggests that “throwing money at the problem” is not enough (Figs. 8 and 9). Successful programs must offer an adequate financial incentive and employ effective marketing strategies. Statistics indicate variations in the effectiveness of marketing efforts; between 45 and 87% of the households receiving promotional literature reported being aware of the programs.

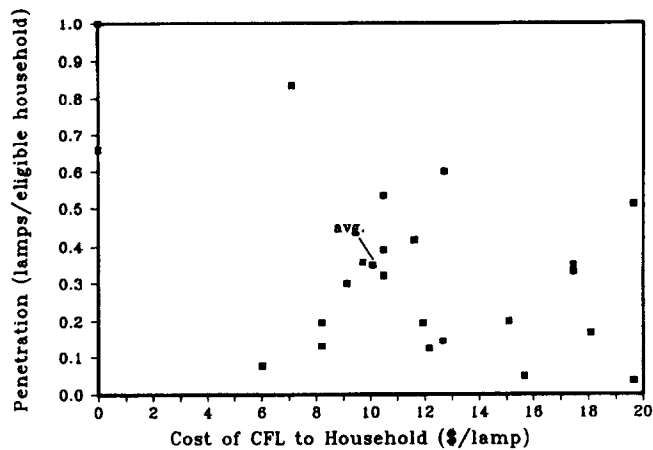


Fig. 8. Customer cost (including taxes) versus program penetration rates. Five programs are off-scale: (18, 8.1), (0, 6), (0, 3.75), and two with the coordinates (0, 2).

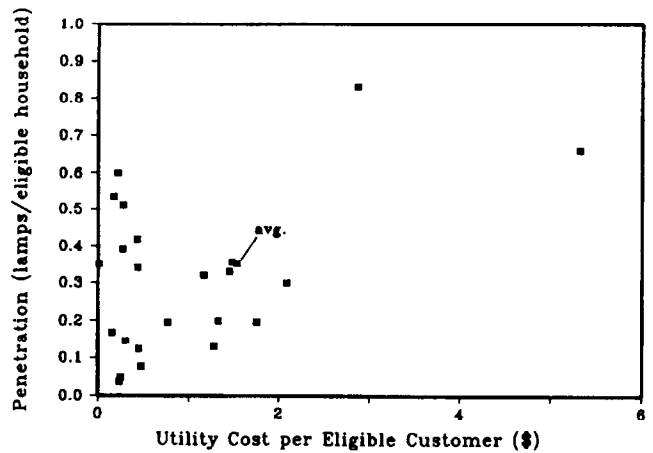


Fig. 9. Utility spending per eligible customer versus program penetration rates. Five programs are off-scale: (55, 6), (15.8, 3.75), (3.4, 8.1), and two with the coordinates (18.5, 2).

Almkvist has offered constructive criticisms of the promotional methods and materials used by European utilities in their CFL programs.²⁶ He identified as a widespread problem the tendency of utilities to take the naive approach of failing to segment the market according to likely consumer needs and motivations. For example, retired people and lower-income groups have not been specially targeted. He also argues that existing programs have appealed mostly to those already convinced. It may also be helpful to introduce an actor other than the utility to communicate programs to the target audience. This has been effective in the U.S., where programs with non-utility sponsors attained substantially higher participation rates than those with utility sponsors.²⁷

Information alone is a weak tool for promoting energy efficiency. Participation rates tend to be significantly lower and overall lamp costs higher when utility efforts are focused only on providing consumer information. In a recent German program in Schleswig-Holstein, an intensive informational effort was conducted, focusing on environmental benefits of using CFLs but offering no financial incentives.²⁸ The impact of this program (CFLs/eligible household) was one-tenth that of the financial-incentive programs shown earlier in Table 2. The information program conducted in 1990 by Stockholm Energi achieved only 25% of the participation of its 1988 program and 35% of their 1989 program.

IDENTIFYING AND OVERCOMING MARKET BARRIERS

Many groups (consumers, utilities, governments, lighting equipment manufacturers, distributors, and retailers) have been involved in and affected by lighting programs. Because there are potential conflicts (real and perceived) among these groups, as well as potential synergisms, all of their interests should be taken into consideration during the design, implementation, and evaluation stages. These groups can all benefit from increased use of energy-efficient technologies, and greater success can be achieved if they cooperate to maximize program effectiveness. Utilities are often unaccustomed to marketing products other than electricity and have difficulties helping consumers match specific efficient products to their needs. Programs with joint utility-manufacturer cooperation tend to attain greater success than programs in which utilities do not cooperate with the lighting industry.

Concern has been raised that parties traditionally involved in lamp sales (e.g. wholesalers, distributors, or retailers) can lose sales or profits as a result of lighting programs conducted by parties who are not usually involved. Utility-sponsored giveaway programs are an obvious case in point. However, three factors should be taken into consideration. First, most program participants would not have bought CFLs without the program, and hence do not represent a lost sales opportunity. Second, even in cases where retailer profits are reduced because of rebates, lamp sales through normal channels will ultimately be enhanced as participants replace their CFLs. In the extreme case, lamp giveaway programs (as in SEAS or Helsingborg) can increase the percentage of households having CFLs by ten-fold or more. In this case, only a small portion of participating households needs to repurchase CFLs in the future to compensate retailers for the effects of earlier discounts or lamp giveaways. Third, as noted above, indirect sales resulting from the programs are often comparable to the sales associated with, for example, rebate checks. These indirect sales provide the full profit margins to those involved in sales. As in the case of EDF's program in Guadeloupe, utilities can offer rebates to retailers.

Lamp shortages have created severe market disruptions. According to manufacturers, there is a global shortage of CFLs today. As suggested earlier by Fig. 1, the surge of CFL sales has put a tremendous strain on lamp production capacity. The recent Swedish NUTEK program achieved exceedingly low success rates (one-tenth of similar programs) because inventories of lamps were exhausted during the opening days of the program and could not be replenished.²⁹ Utilities and manufacturers should work together to ensure an adequate supply of CFLs and appropriate program timing. It is in the interest of both parties that the demand for CFLs does not dramatically (and embarrassingly) exceed the supply. It is unfortunate that there is no coordinated feedback among European utilities, the lighting manufacturers, and others not traditionally involved in lamp distribution. Such coordination has recently been initiated in the U.S.²¹

Finally, while utilities in at least five of the countries where lighting programs have been conducted are in principle allowed to increase tariffs to recover program costs and lost net revenues resulting from decreased electricity sales, they have no clear financial incentive to invest in energy efficiency rather than new supply.³⁰ However, within a short period of time it is possible to institute reforms to utility regulation and other mechanisms to ensure that investing in energy efficiency is profitable to energy suppliers and to society as a whole.

DIFFERENCES BETWEEN EUROPEAN AND U.S. PROGRAMS

Distinct differences exist between the energy-efficient lighting programs in Europe and in the U.S. In general, European programs have had more direct and active manufacturer involvement,

higher consumer participation rates, and lower costs of conserved energy.^{31,32} Published post-program surveys tend to be more detailed in Europe, and government involvement has been greater than in the U.S. (CFL programs have yet to be held in Eastern Europe or the former Soviet Union, but the potential energy savings is substantial there and the need for improved efficiency is acute.)^{33,34}

On the other hand, marketing is more naive in Europe, program duration tends to be shorter, and the technological focus is much narrower than in the U.S. More effort is spent on market segmentation in the U.S., more evolved evaluation methods are used, and more sophisticated approaches for estimating energy impacts have been employed. Financial-incentive programs in Europe have focused almost exclusively on CFLs and on the residential sector. In the U.S., on the other hand, a broad spectrum of lighting technologies (lamps, ballasts, fixtures, controls) has been promoted, with least effort spent in the residential sector. National lighting efficiency standards are being developed in the U.S. and are already in place at the local level, and voluntary government programs have been established such as the U.S. Environmental Protection Agency's Green Lights program and the Federal Energy Management Program (FEMP).³² Such policies and programs have not yet been seriously considered in Europe. Lastly, non-utility parties (e.g. energy service companies) are more well established as purveyors of energy-efficiency services in the U.S. than in Europe.

CONCLUSIONS:

TOWARDS EXPANDED USE OF ENERGY-EFFICIENT LIGHTING

Given the experiences to date, it is possible (and economically justifiable) to implement wide-reaching financial-incentive programs for efficient lighting. Many implementation strategies and technologies can be used without further technical development or institutional changes. In the longer term, technology improvements will increase the number of potential applications for efficient lighting. For example, the introduction of dimmable CFLs would have a big effect. In addition, more lamp shapes and sizes, more choices of lighting color/quality, and a variety of fixtures that can accommodate CFLs are needed. European energy-efficiency programs should now be targeted at a broader range of technologies and energy end uses.

An important finding is that the quality and comprehensiveness of program data are uneven. To improve the understanding of conservation programs, utilities and other actors should ensure that program evaluation is an integral part of the implementation and data-collection process. These concerns notwithstanding, the following conclusions can be drawn: (i) energy-efficiency programs can build new markets; (ii) the programs have been highly cost effective, and administrative costs have been low; (iii) success is not simply proportional to utility spending; (iv) information is less effective than financial incentives; (v) no single incentive is right for all groups; (vi) lowering the cost of CFLs can be more effective in stimulating their use than increasing the price of energy; (vii) product shortages can jeopardize a program's success; (viii) cooperation among utilities, trade allies, and governments is essential; and (ix) more work must be done to better understand consumer motivations.

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